

A decorative graphic on the left side of the slide, featuring a blue and yellow abstract shape at the bottom, a white grid pattern, and a blue sky with clouds and a white jet streaking across it.

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# **Conflict Detection Operational Performance Assessment**

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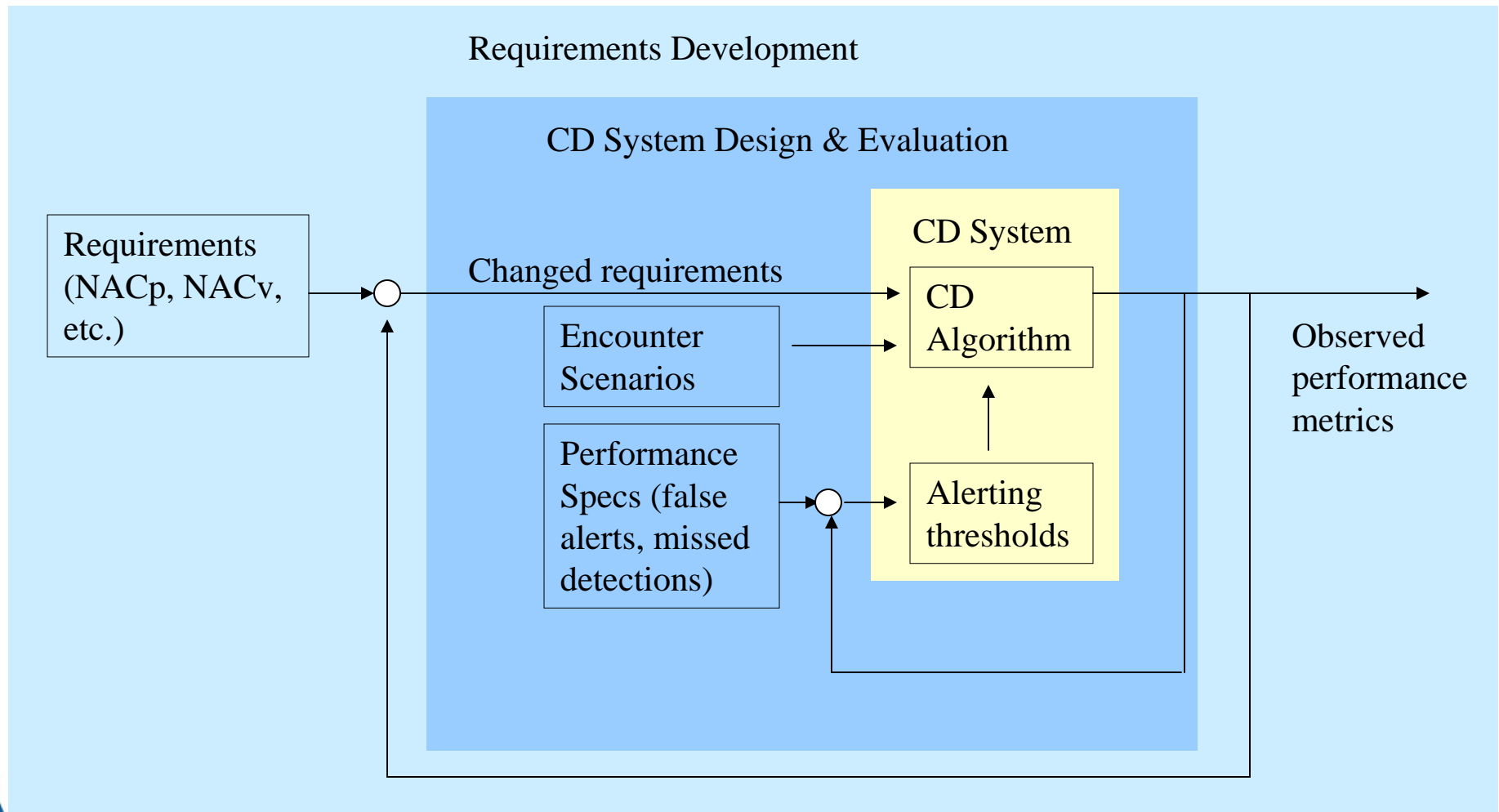
# Outline

- **Purpose**
- **Analysis process**
- **Performance metrics**
- **Algorithm**
- **Data**
- **Method**
- **Requirements**

# Purpose

- **To establish the requirements for the CD application:**
  - NAC<sub>p</sub>
  - NAC<sub>v</sub>
  - Update period
  - Report time accuracy
  - Latency
- **DO-289 ASA MASPS, Section D.2.4**

# CD Analysis Process



# Performance Metrics

- Average duration of false alerts per non-violation encounter
- Average number of missed detections per violation encounter

# Algorithms

- **Alerting criteria**
  - **Collision Avoidance Zone (CAZ)**
  - **Collision Detection Zone (CDZ)**
- **CAZ – projection of closest point of approach**
  - **Alert when thresholds are predicted to be violated**
    - **TCPA**
    - **HMD**
    - **VMD**
- **CDZ – project when protection volume will be violated**

# CAZ: Calculate HMD and CPA with a full state vector

$$dx = x_o - x_i$$

$$dy = y_o - y_i$$

$$d\dot{x} = \dot{x}_o - \dot{x}_i$$

$$d\dot{y} = \dot{y}_o - \dot{y}_i$$

$$\rho(t) = [(dx + t d\dot{x})^2 + (dy + t d\dot{y})^2]^{1/2} \quad (1)$$

Differentiating (1) with respect to time,

$$t_{CPA} = - \frac{(dx)(d\dot{x}) + (dy)(d\dot{y})}{(d\dot{x})^2 + (d\dot{y})^2}$$

The horizontal miss distance,

$$hmd = \frac{(dx)(d\dot{y}) - (dy)(d\dot{x})}{\sqrt{(d\dot{x})^2 + (d\dot{y})^2}}$$

The height difference at time of CPA,

$$dh_{TCPA} = (h_o - h_i) + t_{CPA} (\dot{h}_o - \dot{h}_i)$$

If  $(hmd < T_{hmd} \text{ and } dh_{TCPA} < T_h \text{ and } t_{CPA} < T_t)$  then alert.

# For CDZ Alerting, Use Another Simple Algorithm

Using time of closest point of approach estimate, calculate time of separation boundary violation start and end:

$$T_{Hstart} = t_{cpa} - \sqrt{\frac{C_h^2 - hmd^2}{d\dot{x}^2 + d\dot{y}^2}} \quad (1)$$

Where  $C_h$  is the horizontal alarm. Of course if  $T_{Hstart}$  is less than 0, there is no violation. The end of the violation occurs at time:

$$T_{Hend} = t_{cpa} + \sqrt{\frac{C_h^2 - hmd^2}{d\dot{x}^2 + d\dot{y}^2}} \quad (2)$$

Simultaneously, one can calculate a the start and end of any vertical violation:

$$\begin{aligned} T_{Vstart} &= \frac{[|dz| - C_v]}{|d\dot{z}|} \\ T_{Vend} &= \frac{[|dz| + C_v]}{|d\dot{z}|} \end{aligned} \quad (3)$$



## CDZ Alerting, continued

- **If there is overlap of the vertical and horizontal violation times, then alert.**

# Data

- **For terminal and en route operation scenarios, real operational data (ARTS) were used**
  - Recorded at 11 facilities
  - Contain about 4,000 encounters
- **For GA traffic pattern operations, representative scenarios developed by RTCA SC 186 WG 1 were used**

# Method

- **Pick a set of initial values for update period, report time accuracy and latency, ran simulation using different NACp and NACv values.**
- **Find minimum acceptable NACp and NACv values.**
- **Relax the other parameters until finding the minimum acceptable value of report time accuracy and maximum accepted values of update period and latency.**

# Requirements

- **Recommended values**
  - **NACp (category): 5 (0.5NM)**
  - **NACv (category): 2 (horizontal 3m/s, vertical 4.57 m/s)**
  - **Update period (second): 10**
  - **Report time sigma (seconds): 0.4**
  - **Latency (seconds): 3**